REMARKS

Claims 17 - 22 and 25 - 26 which are withdrawn under a restriction requirement are cancelled herein.

Claim Rejections Under 37 CFR § 112

Claims 36 - 41 and 48 - 53 are rejected under 37 CFR § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. In particular, the Examiner is concerned that Claims 36 - 39 and 48 - 51 include recitations pertaining to additional etch steps which create an element of uncertainty which is carried out into dependent Claims 40, 41, 52, and 53.

In Claims 36 - 39 and 48 - 51, the term "second etch step" has been changed to "first additional step" to make it clear that the etch step in question is the first etch step of the "at least one additional etch step". Similarly, the term "third etch step" has been changed to "second additional etch step" to make it clear that the etch step in question is the second additional etch step of the "at least one additional etch step".

In light of the amendments to Claims 36 - 39 and 48 - 51, applicant respectfully requests withdrawal of the rejection of Claims 36 - 41 and 48 - 53 under 37 CFR § 112, second paragraph.

Claim Rejections Under 35 USC § 102

Claims 47 - 49 are rejected under 35 USC § 102(a) as being anticipated by U.S. Patent No. 5,891,807, to Muller et al.

Applicants respectfully contend that their invention as claimed in Claim 47, and claims which depend therefrom, is not anticipated by the Muller et al. reference. Muller et al. does not teach or even suggest the combination of applicant's step 1) in which a substrate is etched to a predetermined depth to form a shaped opening, followed by a distinct and independent step b) in which a conformal

protective layer is created over the previously etched shaped opening. The Muller et al. reference teaches a sidewall passivation which occurs throughout the entire etching process, with no independent step in which a conformal protective layer is created over a previously etched feature.

In particular, Muller et al. discloses a two-step method of forming a bottle-shaped trench in a substrate. The method includes the steps of: a) etching at a first temperature to form a trench having a tapered top portion; and b) continuing to etch at a second temperature, the second temperature being higher than the first temperature. In an alternative embodiment, in place of or in addition to the change in temperature, the first etch step is conducted at a first pressure and etching is continued at a second pressure that is less than the first pressure. The etchant plasma remains constant during both the first and second steps.

By contrast, applicant's independent Claim 47 (from which Claims 48 and 49 depend) includes at least four steps: etching a substrate to a predetermined depth to form a shaped opening; forming a conformal protective layer overlying at least a sidewall of the shaped opening, where the protective layer comprises a material having a different etch selectivity than the substrate; a subsequent shaped cavity etch step during which the substrate underlying the etched opening is etched to form a shaped cavity using an initial process chamber pressure; and, at least one additional etch step during which continued etching of the shaped cavity is performed using a process chamber pressure that is at least 25% lower than the process chamber pressure during the initial shaped cavity etch step.

On page 3 of the present Office Action, the Examiner cites Muller as teaching that a sidewall passivation layer forms in the first stages of the etching process, and states that "As Muller is etching silicon with an oxygen containing plasma, the sidewall passivation would inherently comprises silicon dioxide". Applicants agree that there is inherent sidewall passivation during the etch process. As a result, the Muller et al. method provides a tapered trench, as described in the Muller et al. reference. The trench is tapered as a result of the passivation materials generated during the etching step, where the passivation materials are a byproduct of the etching process.

By contrast, applicant carries out an etch process to form a shaped opening and then deposits a conformal protective layer in a separate processing step. Applicant's protective layer protects the profile of the shaped opening during subsequent etching of an underlying shaped cavity (see Page 8, lines 12 - 14, of applicant's originally filed Specification). By applying the protective layer subsequent to etching of the opening, the protective layer formation does not interfere with the etch profile obtained during etching of the opening. As a result, the profile of applicant's shaped opening is different from the tapered trench obtained by Muller et al.

It is also important to mention that in applicant's Summary of Invention, at Page 4, lines 13 - 17, applicants describe the plasma source gas used to form the shaped opening/cavity which is formed in the initial etch step. When the substrate is polysilicon,; the plasma source gas typically includes SF_6 and/or Cl_2; when the substrate is silicon oxide, the plasma source gas typically includes CF^4 or NF_3; when the substrate is silicon nitride, the plasma source gas typically includes Sf_6; when the substrate is a metal, the plasma source gas typically includes Cl_2; when the substrate is polyimide, the plasma source gas typically includes CF_4 and O_2. It is clear to one skilled in the art reading this general description that O_2 is recommended when the substrate is organic, such as polyimide, where the oxygen species present perform an etchant function rather that an passivant/protective layer forming function. This is logical, since applicants use a subsequent step in their method to form a protective layer over the etched shape opening. There is no need to form a protective layer during the etching of the opening itself. The purpose of the protective layer is to protect the shape of the opening during etching of an underlying cavity – not to affect the shape of the etched opening, as is the case in the Muller et al. reference.

In light of the above distinctions, applicant respectfully requests withdrawal of the rejection of Claims 47 - 49 under 35 USC § 102(a), over Muller et al.

Claim Rejections Under 35 USC § 103

Claims 35 - 37 and 42 - 46 are rejected under 35 USC § 103(a) as being unpatentable over Muller et al., in view of U.S. Patent No. 5,182,234, to Meyer.

Applicants respectfully submit that the Muller et al. and Meyer et al. methods are incompatible and that one skilled in the art would not combine these two references. Muller et al. teaches maintaining a constant oxygen-containing plasma gas composition throughout etch, with a first etch step conducted at a first temperature or pressure and a second etch step conducted at a second temperature or pressure. Meyer et al. teaches maintaining a constant etch temperature and pressure throughout etch (Col. 8, lines 15 - 18), but varies the plasma source gas composition. However, even if there were some way to combine the teachings of these two references, neither of these two references teaches or even suggests applicant's invention, in which a separate, independent step is used to apply a protective layer over a surface of a previously etched feature, to maintain the shape of that previously etched feature during a subsequent etch process. Applicant's protective layer <u>is deliberately formed</u> during a <u>separate processing step</u>, while both Muller and Meyer's passivation layers are formed <u>as a byproduct of the etching process</u>. As a result, one skilled in the art will recognize that applicant can obtain a much thicker protective layer, which is not obtained when the byproduct protective layer is being constantly etched by the ongoing process. This thicker protective layer is advantageous in applicant's method as is evident from reading applicant's disclosure.

In particular, as discussed above, Muller et al. teaches a two phase etch method where the etchant plasma in both phases includes HBr, NF3, and either premixed He/O_2 or pure O_2. (Col. 3, lines 54 - 55.) The use of the oxygen during etching of the first silicon trench produces a tapered profile. The method includes the steps of: a) etching at a first temperature to form a trench having a tapered top portion; and b) continuing to etch at a second temperature, the second temperature being higher than the first temperature. In an alternative embodiment, in place of or in addition to

the change in temperature, the first etch step is conducted at a first pressure and etching is continued at a second pressure that is less than the first pressure. (Col. 4, lines 47 -49.)

Meyer discloses etching of a dopant-opaque layer of polysilicon to serve as a pattern definer. A profile tailored trench is etched using an SF_6 / O_2 etching composition wherein both isotropic and anisotropic etching are achieved by varying the amount of oxygen in the source gas. (Title) The trench etch process is a two-step process in which the first part of the trench is etched in a silicon substrate using an isotropic etch process utilizing a source gas of SF_6 and He. The second part of the trench is etched using an anisotropic etch process "adding a passivating gas such as oxygen. . . . .that reacts with the trench sidewalls to form a thin SiO_2 passivating layer, <u>at the same power and pressure</u> to continue the trench deeper. . ." (Col. 7, line 64, through Col. 8, line 25)

Meyer is cited by the Examiner as teaching that SF_6 and Ar are functional equivalents to Muller's NF_3 and He. Applicants believe it is generally known in the art that in terms of ion bombardment, argon is known to provide a considerably higher etch rate than helium at a given set of etch conditions, due to the greater mass of the argon species in comparison to the helium species. In any case, as mentioned above, Muller et al. teaches maintaining a constant oxygen-containing plasma gas composition throughout etch, while altering either the temperature of pressure, while Meyer et al. teaches maintaining a constant etch temperature and pressure throughout etch, but varies the plasma source gas composition.

Further, in the Muller et al. method, a passivating gas which produces a protective layer is used constantly throughout the etch process. In the Meyer method, no passivating gas is used during the initial isotropic etch step and varying amounts of passivating gas are used during an anisotropic second etch, to produce a particular sidewall spacer structure on a trench. In applicant's method as claimed in amended independent Claim 35, a single crystal silicon substrate is etched using a plasma generated from a source gas consisting essentially of SF_6 and argon (as described in applicant's Specification in the embodiment illustrated in Table 1). After etching of an initial shaped cavity, a second etch step is carried out at a process chamber pressure which is at least 25 % lower than the

process chamber pressure during the initial cavity etch. Applicant's method is patentably distinct from the Muller et al. disclosure since there is no presence of a passivation gas which affects cavity profile during the initial etch step. Applicant's method is patentably distinct from the Meyer disclosure, which uses no passivating gas during the initial etch, but uses a variable amount of passivating gas during the final etch step, with no intermediate step to apply a protective coating over the opening which was produced during the initial etch step.

In addition, the Muller et al. method, although generally stated, is illustrated only with respect to a silicon wafer 10 (Col. 2, line 51). Silicon wafers are generally single crystal silicon. Thus, Muller et al. teaches that an oxide passivant needs to be present during the entire etching of the single crystal silicon substrate, teaching away from applicant's invention.

Finally, as mentioned above, applicant's protective layer is deliberately formed during a separate processing step. By contrast, both Muller's and Meyer's passivation layers are formed as a byproduct of the etching process. As a matter of interest, referring to Page 15, lines 12 - 17, of applicant's originally filed Specification, applicant's protective layer typically has a thickness ranging from about 1000 Å to about 2000 Å. This shows one advantage of a separate application of the protective layer, as one skilled in the art will recognize that a passivation layer which is a byproduct of an etching process would not typically reach a thickness as great as 1000 Å.

In light of the above distinctions, applicant respectfully requests withdrawal of the rejection of Claims 35 - 37 and 42 - 46 under 35 USC § 103(a), over Muller et al., in view of Meyer.

Claims 5 - 10, 12 - 16, 23, 24, and 27 - 34 are allowed.

Claims 38 - 41 and 50 - 53 are indicated to be allowable if rewritten to overcome the rejection(s) under 35 USC § 112, second paragraph, and to include all of the limitations of the base claim and any intervening claims. As set forth above, Claim 36 (from which Claims 38 - 41 depend) and Claim 48 (from which Claims 50 - 53 depend) have been amended to remove any potential ambiguity.

Applicant asserts that all presently pending claims are in condition for allowance, and the Examiner is respectfully requested to pass the application to allowance.

The Examiner is invited to contact applicant's attorney with any questions or suggestions, at the telephone number provided below.

Respectfully Submitted,

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AMENDMENT "B" UNDER 37 CFR § 1.111
VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claims 35 - 39 and 48 - 51 have been amended as follows.

35. (Once amended) A method of etching a shaped cavity in a single crystal silicon substrate, wherein the method comprises:

a) an initial cavity etch step during which said single crystal silicon substrate is etched to form a shaped cavity using an initial process chamber pressure; and

b) at least one additional etch step during which continued etching of said shaped cavity is performed using a process chamber pressure that is at least 25% lower than said initial process chamber pressure,

wherein [said substrate comprises single-crystal silicon, and wherein] etching is performed using a plasma generated from a source gas [comprising] consisting essentially of SF_6 and Ar.

36. (Once Amended) The method of Claim 35, wherein said at least one additional etch step includes a [second] first additional etch step which is performed using a process chamber pressure that is within a range of about 30% to about 50% lower than said initial process chamber pressure.

37. (Once Amended) The method of Claim 36, wherein said [second] first additional etch step is performed using a process chamber pressure that is about 30% lower than said initial process chamber pressure.

38. (Once Amended) The method of Claim 37, wherein said at least one additional etch step further includes a [third] second additional etch step during which continued etching of said shaped

cavity is performed using a process chamber pressure that is at least 40% lower than the process chamber pressure used during the performance of said [second] first additional etch step.

39. (Once Amended) The method of Claim 38, wherein said [third] second additional etch step is performed using a process chamber pressure that is within a range of about 40% to about 50% lower than the process chamber pressure used during the performance of said first additional etch step [b)].

48. (Once Amended) The method of Claim 47, wherein said at least one additional etch step includes a [second] first additional etch step which is performed using a process chamber pressure that is within a range of about 30% to about 50% lower than said initial process chamber pressure.

49. (Once Amended) The method of Claim 48, wherein said [second] first additional etch step is performed using a process chamber pressure that is about 30% lower than said initial process chamber pressure.

50. (Once Amended) The method of Claim 48, wherein said at least one additional etch step further includes a [third] second additional etch step during which continued etching of said shaped cavity is performed using a process chamber pressure that is at least 40% lower than the process chamber pressure used during the performance of said [second] first additional etch step.

51. (Once Amended) The method of Claim 50, wherein said [third] second additional etch step is performed using a process chamber pressure that is within a range of about 40% to about 50% lower than the process chamber pressure used during the performance of said first additional etch step [d)].